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(54) **Particulate trap**

Partikelabscheider

Piège à particules

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Description

This invention relates to a particulate trap for collecting and removing particulates such as carbon contained in exhaust gas discharged from a diesel engine.

Exhaust gas discharged from cars is a major cause of air pollution. It is very important to develop techniques for removing harmful components contained in the exhaust gas. It is especially important to develop techniques for removing particulates in the exhaust gas discharged from diesel engines, which contain NOx and carbon.

Heretofore, various efforts have been made to remove such harmful components from the exhaust gas. Such efforts include putting EGR (exhaust gas recirculation) on the engine and improving the fuel injection system. But none of them has been a decisive solution. Another known measure is to provide an exhaust trap in the exhaust passage to collect the particulates in the exhaust gas (as proposed in Unexamined Japanese Patent Publication 58-51235). This after-treatment method is considered the most practical and has been studied vigorously.

A particulate trap for collecting particulates contained in the exhaust gas has to meet the following requirements in view of the conditions of use:

1) Collecting capacity

First, it has to be capable of collecting particulates with such high efficiency that the exhaust gas is cleaned sufficiently. The amount of particulates contained in the exhaust gas depends on the displacement of the diesel engine and the load applied. It is generally considered that such a trap has to be capable of collecting at least 60% of the particulates in the exhaust gas.

2) Pressure drop

Secondly, such a trap must not unduly prevent the flow of exhaust gas. As the amount of the particulates collected by the trap increases, the pressure drop increases gradually. If such pressure drop is too high, an undesirable back pressure will act on the engine. It is considered necessary to keep such pressure drop below 30 KPa. For this purpose, it is necessary to use a particulate trap which is low not only in initial pressure drop but also keeps the pressure drop low even after it has collected particulates.

3) Regeneration

Thirdly, such a trap has to permit regeneration without requiring much energy. In other words, the trap has to have means for burning the collected particulates to regenerate it. One conceivable device for burning particulates is a light oil burner. But considering the safety and ease of control, an electric heater is considered more promising. But the trap has to be regenerated without consuming too much electric power because the capacity of a battery on a car is limited.

A wall-flow type honeycomb-shaped porous member made of cordierite ceramic is considered most practical as the filter element material in the particulate trap. But with this type of filter, particulates tend to collect in a limited area. Further, due to low heat conductivity of cordierite ceramic, heat spots tend to develop when burning particulates. Thus, the filter may melt or develop cracks due to thermal stress. Such a filter is therefore not reliable enough.

Much attention is now directed to a metal trap and a ceramic fiber trap comprising candle-shaped ceramic fiber, because these traps never develop cracks and thus are sufficiently reliable.

Such traps have a structural problem in that their filtration area through which exhaust gas can pass is small compared with a cordierite ceramic filter. If the filter is designed so as to show increased particulate collection efficiency, the particulates will be collected only on the surface of the filter, thus clogging it. The clogged filter will sharply increase the pressure drop. Thus, the life of such a filter is very short.

These filters have another disadvantage which is observed when burning particulates to regenerate them. Namely, whereas a cordierite ceramic filter can burn particulates with less power consumption because it heats itself up while burning the collected particulates and the heat thus generated is propagated to the particulates, metal traps and ceramic fiber traps cannot collect so much amount of particulates as the cordierite ceramic filter and thus they are not heated to a sufficient degree. This means that the particulates have to be burned practically solely by the heat produced by the electric heater. Thus, the electric heater consumes much electric power.

From EP-A-0 502 826, e.g. a filtering device for removing soot from exhaust gas is known, using filters which comprise one ceramic cylindrical filter body and one heating element, respectively, with at least three filters being arranged in parallel with respect to the direction of flow.

An object of the present invention is to provide a particulate trap which solves these problems.

According to the present invention, a particulate trap for use in a diesel engine comprises the features of claim 1.

Also, it is preferable to form the filter element from at least two different kinds of filter materials whose pore diameters

are different from one another so that the material having large-diameter pores is arranged nearer to the exhaust gas inlet side than is the material having small-diameter pores. This makes it possible to prolong the pressure drop life of the filter element, reduce its weight and heat capacity and thus to regenerate it in a shorter period of time.

The filter element should preferably be made of a three-dimensional mesh-like porous metal member, an unwoven metal web or a three-dimensional mesh-like porous metal member having its pores stuffed with ceramics or metal to reduce their diameter.

The above-mentioned filter materials, i.e. the three-dimensional mesh-like porous metal member (A), an unwoven metal web (B), and the three-dimensional mesh-like porous metal member having its pores stuffed with ceramics or metal to reduce their diameter (C), are used in combination so that the material having larger-diameter pores is arranged nearer to the exhaust gas inlet side than is the material having smaller-diameter pores. They can be combined in the following manner:

(1) A + A, (2) B + B, (3) C + C, (4) A + B, (5) A + C, (6) B + C, (7) A + B + C

By interposing the electric heater between the opposed surfaces of the filter element, it is possible to increase the filtration area of the filter through which exhaust gas can pass compared with a conventional filter having a candle structure. Thus, the filter element of the present invention shows a prolonged pressure drop life.

Further, with this arrangement, since the heat produced by the electric heater is confined in a narrow space between the opposed surfaces of the filter, the collected particulates can be heated efficiently. Thus, the electric heater consumes less electric power for regeneration.

Further, since the filter element is arranged so that its pores nearer to the exhaust gas inlet side have larger diameters than those nearer to the outlet side, particulates can be collected uniformly over the entire area of the filter in the direction of thickness. The filter is thus less likely to clog. This leads to a prolonged pressure drop life and a lighter filter weight and thus a shorter regeneration time. Shorter regeneration time means lesser electric power consumption.

The particulate trap of the present invention has its electric heater for burning collected particulates interposed between the opposed surfaces of the filter elements so as not to interfere with the flow of exhaust gas. Thus, the collected particulates will not increase the pressure drop of the filter, so that its particulate collection capacity is kept high for a prolonged period of time.

Also, the particulates can be burned efficiently by the electric heater with lesser electric power consumption. This invention is therefore especially suitable for application to diesel engine cars for which there is a growing demand for measures to clean their exhaust gas and the battery capacity is limited.

Other features and objects of the present invention will become apparent from the following description made with reference to the accompanying drawings, in which:

Fig. 1 is a schematic view of the experimental device used for the evaluation of particulate collection capacity;
Fig. 2 is a perspective view showing the main component (filter element with a built-in heater) of the particulate trap of the present invention;
Fig. 3 is a sectional view of the filter element of the same;
Fig. 4 is a perspective view of another embodiment of the heater-carrying filter element;
Fig. 5 is a sectional view of the filter element of Fig. 4;
Fig. 6 is a perspective view of a conventional heater-carrying cylindrical filter element;
Fig. 7 is a graph showing the relation between the pressure drop and the accumulated PM (particulate matter) amount;
Fig. 8 is a graph showing the relation between the particulate collection efficiency and the accumulated PM amount;
Fig. 9 is a table showing the recovery rate of the pressure drop when particulates are burned;
Fig. 10 is a graph similar to the graph of Fig. 7 for the second embodiment;
Fig. 11 is a graph similar to the graph of Fig. 8 for the second embodiment;
Fig. 12 is a table showing the recovery rate of the pressure drop when particulates are burned in the second embodiment;
Fig. 13 is a graph similar to the graph of Fig. 7 for the third embodiment;
Fig. 14 is a graph similar to the graph of Fig. 8 for the third embodiment; and
Fig. 15 is a table showing the recovery rate of the pressure drop when particulates are burned in the third embodiment.

Fig. 1 shows an apparatus for experiment. It comprises a 3400 cc, four-cylinder, direct-injection diesel engine car, a chassis dynamometer and a dilution tunnel.

(First Embodiment)

Fig. 2 shows the first embodiment of the particulate trap for use in a diesel engine according to the present invention. It comprises cylindrical filters 1 and 2 having different diameters and nested together and an electric heater 3 disposed therebetween. This filter element 10 with a built-in heater is mounted in a case 11 shown in Fig. 1.

Fig. 3 shows a sectional view of the filter element 10 shown in Fig. 2. Exhaust gas is introduced into between the filters 1, 2. Part of the gas flows through the filter 1 to its outside and the remaining part flows through the filter 2 into its inside. In order to create this gas flow, the gas inlet side and the opposite end face are sealed by iron plates 4 through gaskets.

The filters in this embodiment were cylindrical members formed by adding Cr to a Ni-based three-dimensional mesh-like porous member (trade name: Cermet) made by Sumitomo Electric Industries, Ltd. The heater 3 comprises a cylindrical member made of punching metal and a sheath heater 4 mm in diameter wound around the cylindrical member.

Experiments were conducted using a particulate trap (specimen A) having eight filter elements 10 as shown in Fig. 2 mounted in a case.

For comparison purposes, experiments were also done on a trap having a cylindrical structure (specimen B) shown in Fig. 6, which is employed in ordinary metal traps and ceramic fiber traps. The specimen B comprises seven filter elements mounted in a case, each element comprising a filter 12 made of the same material as the specimen A and four sheath heaters 13 arranged at the pitch of 90°.

Table 1 shows the specifications of the specimens A and B such as dimensions.

[Table 1]

Specimen	Cerment No.	Thickness of material (cermet)	No. of turns	Material	Size	No. of filter elements	Packing density
A	#7	0.9 mm	4	NiCr	Filter 1: φ48×φ39×190L Filter 2: φ29×φ27×190L	7	21.1 %
B	#7	0.9 mm	4	NiCr	φ48×φ39×190L	7	21.2 %
A: according to the present invention B: for comparison							

The item numbers in the table show the number of cells (or pores) in a unit area. #7 has 50 - 70 cells per inch.

The results of experiments are shown in Figs. 7 and 8. The particulate collection capacity of each specimen is represented in terms of the pressure drop and the collection efficiency with respect to accumulated PM amount (amount of particulates). The regeneration is shown in terms of the recovery rate of the pressure drop when the heater power is applied.

These results clearly show that the particulate trap according to the present invention (specimen A) shows an extended pressure drop life and requires less electric power for regeneration.

In the embodiment, a punching metal was heated by the sheath heater to uniformly heat the entire surfaces of the filters by the radiation heat from the punching metal. But the heating medium is not limited to punching metal. It may be expanded metal or an ordinary wire net or porous metal.

It is preferable to use a plate-shaped heater in order to heat the filters uniformly. But this is not an essential requirement. For example, a rod-shaped sheath heater may be interposed between the opposed surfaces of the filters. Moreover, the heater 3 may be in contact with one or both of the opposed surfaces of the filters. Point is that the heater is disposed between the opposed surfaces in such a way as not to interfere with the flow of exhaust gas.

(Second Embodiment)

The experimental apparatus shown in Fig. 1 was used here, too.

The particulate trap of the second embodiment (specimen C) has the same structure as the one shown in Fig. 2 (its section is the same as shown in Fig. 3) but differs therefrom in that the filters are cylindrical members formed from unwoven web of metal fiber. In the embodiment, the unwoven metal web is of an Fe-Cr-Al alloy but may be made of any other material.

The heater is formed by stamping a thin plate of inconel and shaping it into a tube after adjusting its resistance. It

is heated by directly supplying electricity thereto. Of course, the heater may be made of a material other than inconel.

Experiments were conducted for seven sets of the above-described filter elements mounted in a case and each comprising concentrically arranged filters 1, 2 of unwoven metal web and a cylindrical heater 3 made of inconel and disposed therebetween.

For comparison purposes, experiments were also done for a trap having a cylindrical structure (specimen D) shown in Fig. 6, which is employed in ordinary metal traps and ceramic fiber traps. This comparative specimen D comprises seven filter elements mounted in a case, each element comprising a cylindrical filter 12 made of unwoven metal web and four rod-shaped heaters 13 mounted in the filter as shown.

Table 2 shows the specifications of the specimens C and D such as dimensions.

[Table 2]

Specimen	Fiber diameter of metal unwoven web	Thickness of material (metal unwoven web)	No. of turns	Material	Size	No. of filter elements	Packing density
C	30 µm	0.5 mm	2	FeCrAl	Filter 1: $\phi 62 \times \phi 60 \times 190L$ Filter 2: $\phi 50 \times \phi 48 \times 190L$	7	20.0 %
D	30 µm	0.5 mm	2	FeCrAl	$\phi 57 \times \phi 55 \times 190L$	7	20.0 %
C: according to the present invention D: for comparison							

The results of experiments are shown in Figs. 10 - 12. The particulate collection capacity of each specimen is represented in terms of the pressure drop and collection efficiency with respect to accumulated PM amount. The regeneration capacity is shown in terms of the recovery rate of the pressure drop when the heater power is applied. These results clearly show that the specimen C according to the present invention shows an extended pressure drop life and requires less electric power for regeneration.

(Third Embodiment)

The experimental apparatus used here is also the same as the apparatus shown in Fig. 1.

The specimen of the third embodiment (specimen E) is a filter element 10 shown in Fig. 4 (its section is shown in Fig. 5). This filter element comprises a web of filter plate 21 which is folded over many times to provide a plurality of layers and a plurality of plate heaters 23 disposed between the layers. As shown in Fig. 5, exhaust gas is introduced into the gaps defined between the adjacent layers of the filter plate 21. In order to allow the exhaust gas to flow through the filter plate 21, its sides are sealed by iron plates (not shown).

The filter element used as the particulate trap of the third embodiment is made of unwoven web of metal fiber whose diameter decreases gradually from its exhaust gas inlet toward outlet so that the pores nearer to the inlet have larger diameters than those nearer to the outlet. The unwoven metal web is made of a Ni-Cr-Al alloy in the embodiment but may be made of any other material.

The plate-shaped heaters 23 are formed by blanking an inconel thin plate and adjusting its resistance. The heaters may be made of a material other than inconel. They may comprise a plate of punching metal and heater wires attached thereto.

The filter element of this embodiment was mounted in a trap case to form the particulate trap of the present invention (specimen E). Its performance was evaluated.

For comparison purposes, a conventional trap having a cylindrical configuration as shown in Fig. 6 (specimen F) was also tested. The specimen F comprises a cylindrical filter made of the same material as the specimen E and four rod-shaped heaters mounted thereto.

Table 3 shows data on the specimens E and F such as dimensions.

[Table 3]

Specimen	Fiber diameter of metal unwoven web	Thickness of material (metal unwoven web)	Material	Shape of filter	Size	No. of filter elements	Packing density
E	40 μm at exhaust inlet 20 μm at exhaust outlet	Total 1.0 mm	NiCrAl	Parallel plane plate	Filter contour: W130×H130×D190	1	20.0 %
F	40 μm at exhaust inlet 20 μm at exhaust outlet	Total 1.0 mm	NiCrAl	Cylindrical	ϕ57×ϕ55×190L	7	20.0 %
E: according to the present invention F: for comparison							

The results of experiments are shown in Figs. 13 - 15. The particulate collection capacity of each specimen is represented in terms of the pressure drop and collection efficiency with respect to accumulated PM amount. The regeneration capacity is shown in terms of the pressure recovery rate when the heater power is applied. These results clearly show that the specimen E according to the present invention shows an extended pressure drop life and requires less electric power for regeneration.

Claims

1. A particulate trap for use in a diesel engine comprising a case (11) provided in the exhaust line of the diesel engine, a filter element (10) mounted in said case (11) and having at least two mutually opposed surfaces defining a gap into which exhausts are introduced, and an electric heater (3) in the form of a metal plate having a first and a second surface opposite to each other for burning particulates collected by said filter element, said filter element (10) being a three-dimensional mesh-like porous member made of a heat-resistant metal having pores, or being made of unwoven metal web, characterized in that said electric heater (3) is mounted in said gap such that said first and second surfaces of said heater (3) oppose directly to said respective opposed surfaces of said filter element (10), spaced from said respective opposed surfaces by a distance not exceeding 20 mm.

2. A particulate trap as claimed in claim 1 wherein said filter element (10) comprises a large-diameter cylindrical filter (1) having an inner cylindrical surface as one of said two mutually opposed surfaces, and a small-diameter cylindrical filter (2) having an outer cylindrical surface as the other of said two mutually opposed surfaces and nested in said large-diameter cylindrical filter, and wherein said electric heater (3) is in the form of a cylindrical metal plate having opposite cylindrical surfaces as said first and second opposite surfaces.

3. A particulate trap as claimed in claim 1 wherein said filter element (10) comprises a plurality of pairs of opposite flat portions having opposite flat surfaces as said mutually opposed surfaces, and wherein said electric heater (3) is in the form of a flat metal plate having opposite flat surfaces as said first and second opposite surfaces.

4. A particulate trap as claimed in any of claims 1 to 3 wherein said porous member is stuffed with ceramics or metal to reduce the diameter of said pores.

5. A particulate trap as claimed in any of claims 1 to 3 wherein said filter element (10) is formed of at least two kinds of three-dimensional mesh-like porous members having pores having different diameters from the pores in the other member, the member having larger pores being provided nearer to an exhaust gas inlet than the member

having smaller pores.

6. A particulate trap as claimed in any of claims 1 to 3 wherein said filter element (10) is formed of two different kinds of unwoven metal webs each having pores having different diameters from the pores in the other web, the web having larger pores being provided nearer to an exhaust gas inlet than the web having smaller pores.

7. A particulate trap as claimed in any of claims 1 to 3 wherein said filter element (10) is formed of at least two of three kinds of materials selected from the group consisting of a three-dimensional mesh-like porous member made of a heat-resistant metal and having pores, a three-dimensional mesh-like porous member having pores and stuffed with ceramics or metal to reduce the diameter of its pores, and an unwoven metal web, the material having larger pores being provided nearer to an exhaust gas inlet than the material having smaller pores.

Patentansprüche

1. Partikelfilter zur Verwendung in einem Dieselmotor, mit einem in der Abgasleitung des Dieselmotors angeordneten Gehäuse (11), einem Filterelement (10), das in diesem Gehäuse (11) angeordnet ist und mindestens zwei gegenüberliegende Flächen aufweist, die eine Lücke bilden, in welche Abgase eingeführt werden, und mit einem elektrischen Heizelement (3) in Form einer Metallplatte, die zum Abbrennen der durch das Filterelement gesammelten Partikel eine erste und eine zweite Fläche aufweist, welche sich gegenüberliegen, wobei das Filterelement (10) als ein aus einem wärmebeständigen Metall mit Poren bestehendes, dreidimensionales, maschenartiges, poröses Element vorliegt, oder aus ungewebtem Metallvlies besteht, dadurch gekennzeichnet, daß das elektrische Heizelement (3) so in der Lücke angeordnet ist, daß die ersten und zweiten Flächen des Heizelements (3) direkt den jeweils gegenüberliegenden Flächen des Filterelements (10) gegenüberliegen, wobei das Heizelement von den jeweils gegenüberliegenden Flächen in einem Abstand von nicht mehr als 20 mm angeordnet ist.

2. Partikelfilter nach Anspruch 1, bei dem das Filterelement (10) einen zylindrischen Filter (1) mit großem Durchmesser aufweist, der als eine der beiden gegenüberliegenden Flächen eine innere zylindrische Fläche aufweist, und einen zylindrischen Filter (2) mit kleinem Durchmesser, der als die andere der beiden gegenüberliegenden Flächen eine äußere zylindrische Fläche aufweist und der in dem zylindrischen Filter mit großem Durchmesser untergebracht ist, und bei dem das elektrische Heizelement (3) in Form einer zylindrischen Metallplatte vorliegt, die gegenüberliegende zylindrische Flächen als erste und zweite gegenüberliegende Flächen aufweist.

3. Partikelfilter nach Anspruch 1, bei dem das Filterelement (10) eine Vielzahl von Paaren gegenüberliegender flacher Bereiche aufweist, die als gegenüberliegende Flächen gegenüberliegende flache Oberflächen haben, und bei dem das elektrische Heizelement (3) in Form einer flachen Metallplatte vorliegt, die gegenüberliegende flache Oberflächen als erste und zweite gegenüberliegende Flächen aufweist.

4. Partikelfilter nach einem der Ansprüche 1 bis 3, bei dem das poröse Element mit Keramik oder Metall gefüllt ist, um den Durchmesser der Poren zu reduzieren.

5. Partikelfilter nach einem der Ansprüche 1 bis 3, bei dem das Filterelement (10) aus mindestens zwei Arten dreidimensionaler, maschenartiger, poröser Elemente besteht, deren Poren andere Durchmesser haben als die Poren in dem anderen Element, wobei das Element mit den größeren Poren näher an einem Abgaseinlaß angeordnet ist, als das Element mit den kleineren Poren.

6. Partikelfilter nach einem der Ansprüche 1 bis 3, bei dem das Filterelement (10) aus zwei unterschiedlichen Arten ungewebter Metallvliese besteht, die jeweils Poren aufweisen, deren Durchmesser sich von dem der Poren in dem anderen Vlies unterscheidet, wobei das Vlies mit den größeren Poren näher an einem Abgaseinlaß angeordnet ist, als das Vlies mit den kleineren Poren.

7. Partikelfilter nach einem der Ansprüche 1 bis 3, bei dem das Filterelement (10) aus mindestens zwei von drei Arten von Materialien besteht, die aus einer Gruppe auszuwählen sind, welche ein dreidimensionales, maschenartiges, poröses Element umfaßt, das aus einem wärmebeständigen Metall besteht und Poren aufweist, sowie ein dreidimensionales, maschenartiges, poröses Element, das Poren aufweist und mit Keramik oder Metall gefüllt ist, um den Durchmesser der Poren zu reduzieren, und ein ungewebtes Metallvlies, bei dem das Material mit größeren Poren näher an einem Abgaseinlaß angeordnet ist als das Material mit kleineren Poren.

Revendications

1. Piège à particules destiné à être utilisé dans un moteur diesel comprenant un boîtier (11) agencé dans une ligne d'échappement d'un moteur diesel, un élément formant filtre (10) monté dans le boîtier (11) et comportant au moins deux surfaces opposées mutuelles définissant une ouverture dans laquelle des gaz d'échappement sont introduits, et un dispositif de chauffage électrique (3) en forme de plaque de métal comportant des première et seconde surfaces opposées l'une par rapport à l'autre pour brûler des particules recueillies par l'élément formant filtre, l'élément formant filtre (10) étant un organe poreux du type à mailles à trois dimensions fabriqué en métal résistant à la chaleur muni de pores, ou bien étant fabriqué en non-tissé métallique, caractérisé en ce que le dispositif de chauffage électrique (3) est monté dans l'ouverture de manière que les première et seconde surfaces de ce dispositif (3) soient opposées directement aux surfaces opposées respectives de l'élément formant filtre (10), et soient espacées de ces surfaces opposées respectives d'une distance n'excédant pas 20 mm.

2. Piège à particules selon la revendication 1, dans lequel l'élément formant filtre (10) comprend un filtre cylindrique (1) de grand diamètre comportant une surface cylindrique interne formant l'une des deux surfaces opposées mutuellement, et un filtre cylindrique (2) de petit diamètre comportant une surface cylindrique externe formant l'autre desdites deux surfaces opposées mutuellement et emboîté dans le filtre cylindrique de grand diamètre, et dans lequel le dispositif de chauffage (3) se présente sous la forme d'une plaque métallique cylindrique comportant des surfaces cylindriques opposées formant lesdites première et seconde surfaces opposées.

3. Piège à particules selon la revendication 1, dans lequel l'élément formant filtre (10) comprend une pluralité de paires de parties planes opposées comportant des surfaces planes opposées formant lesdites surfaces opposées mutuellement, et dans lequel le dispositif de chauffage (3) se présente sous la forme d'une plaque de métal plane comportant des surfaces planes opposées formant lesdites première et seconde surfaces opposées.

4. Piège à particules selon l'une quelconque des revendications 1 à 3, dans lequel l'organe poreux est rempli de céramique ou de métal pour réduire le diamètre des pores.

5. Piège à particules selon l'une quelconque des revendications 1 à 3, dans lequel l'élément formant filtre (10) est formé d'au moins deux sortes d'organes poreux à mailles à trois dimensions comportant des pores présentant des diamètres différents de ceux des pores dans l'autre organe, l'organe comportant les pores de plus grandes dimensions étant agencé plus près d'une sortie de gaz d'échappement que l'organe comportant les pores de plus petites dimensions.

6. Piège à particules selon l'une quelconque des revendications 1 à 3, dans lequel l'élément formant filtre (10) est formé de deux sortes différentes de non-tissé métallique comportant des pores présentant des diamètres différents de ceux des pores de l'autre non-tissé, le non-tissé comportant les pores de plus grandes dimensions étant agencé plus près d'une sortie de gaz d'échappement que le non-tissé comportant les pores de plus petites dimensions.

7. Piège à particules selon l'une quelconque des revendications 1 à 3, dans lequel l'élément formant filtre (10) est formé d'au moins deux parmi trois sortes de matériaux choisis parmi le groupe comprenant un organe poreux à mailles à trois dimensions fabriqué avec un métal résistant à la chaleur et comportant des pores, un organe poreux à mailles à trois dimensions comportant des pores et rempli de céramique et de métal pour réduire le diamètre de ses pores, et un non-tissé métallique, le matériau comportant les pores de plus grandes dimensions étant agencé plus près d'une sortie de gaz d'échappement que le matériau comportant les pores de plus petites dimensions.

FIG. 1

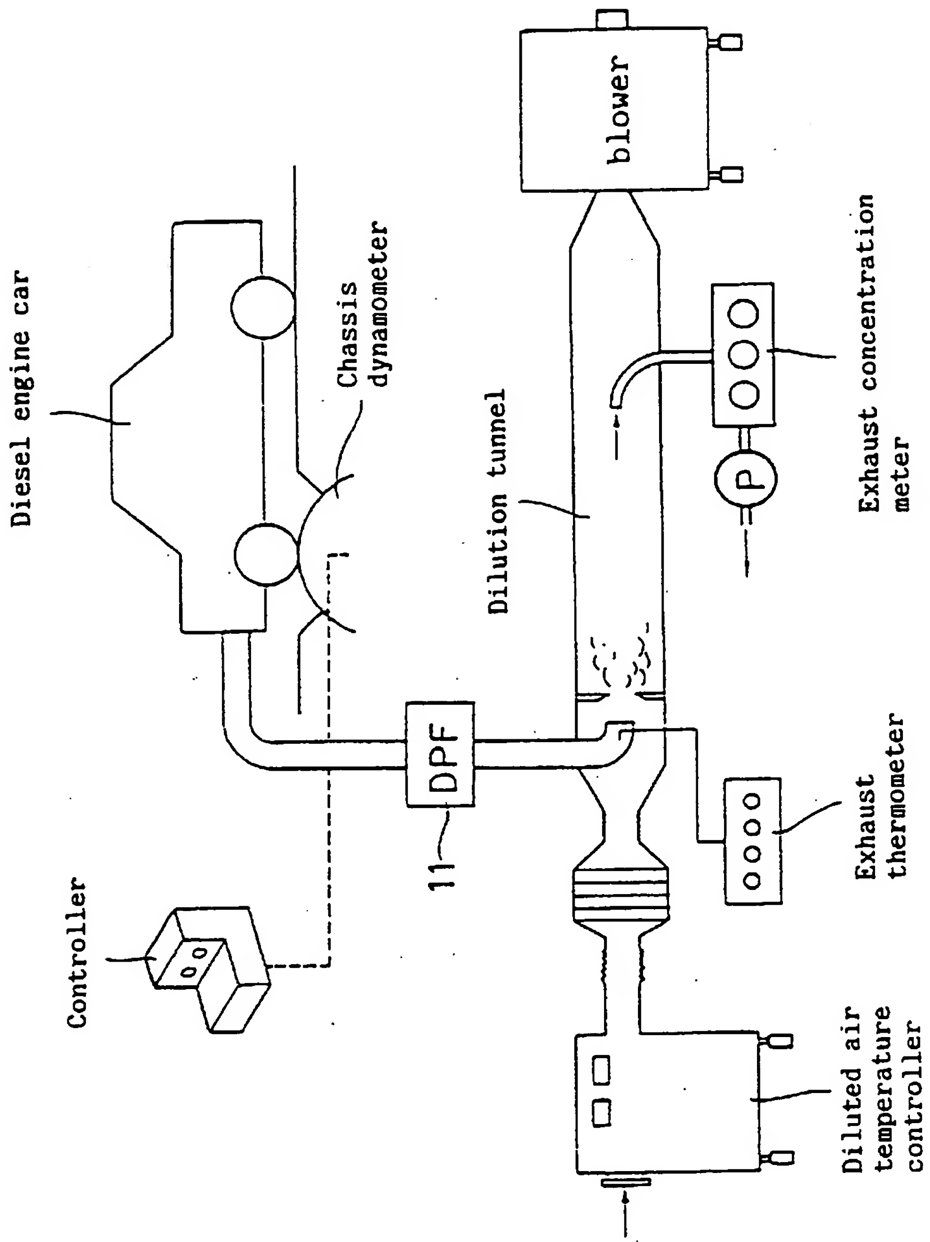
Diesel engine car
Chassis dynamometer
blower
Dilution tunnel
Exhaust concentration meter
P
DPF
11
Exhaust thermometer
Controller
Diluted air temperature controller

FIG. 2

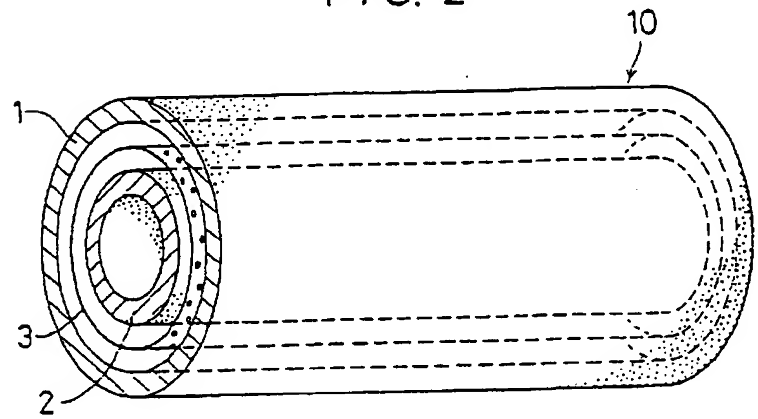

FIG. 3

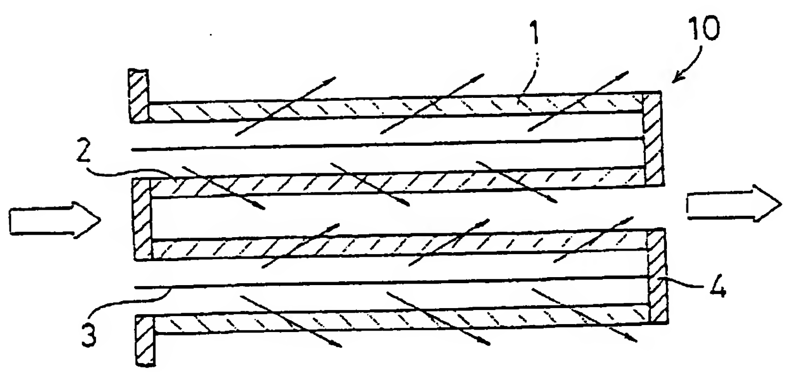

FIG. 4

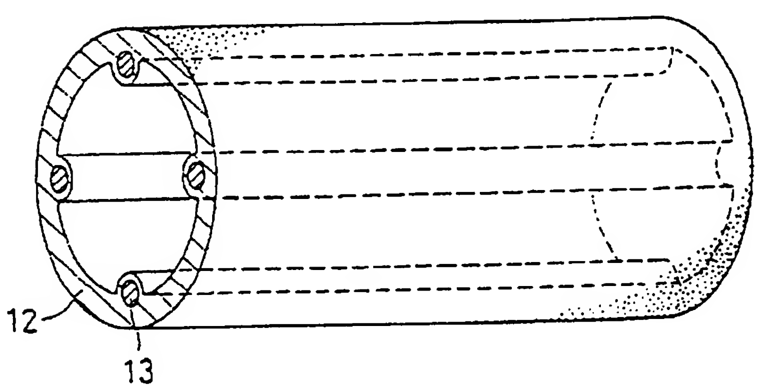

FIG. 5

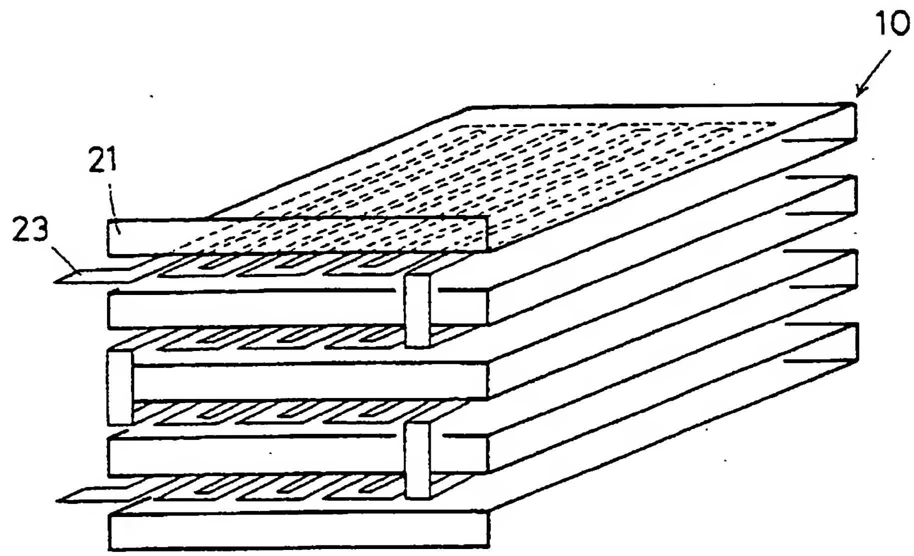

FIG. 6

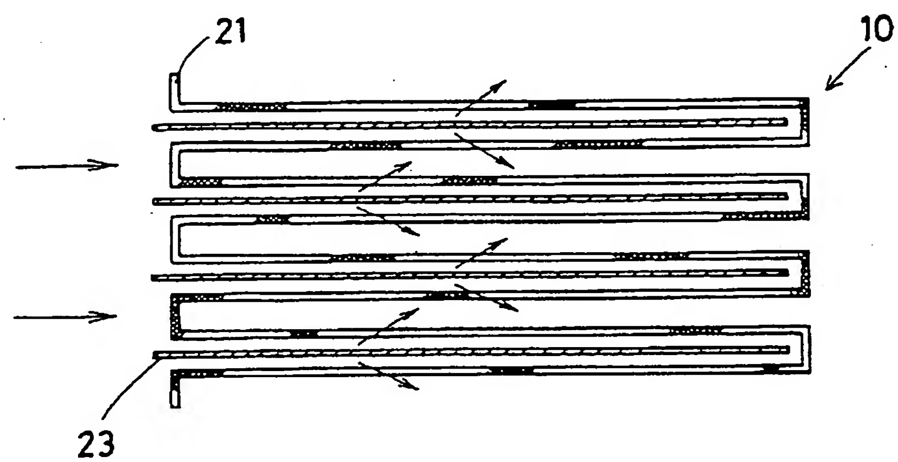

FIG. 7

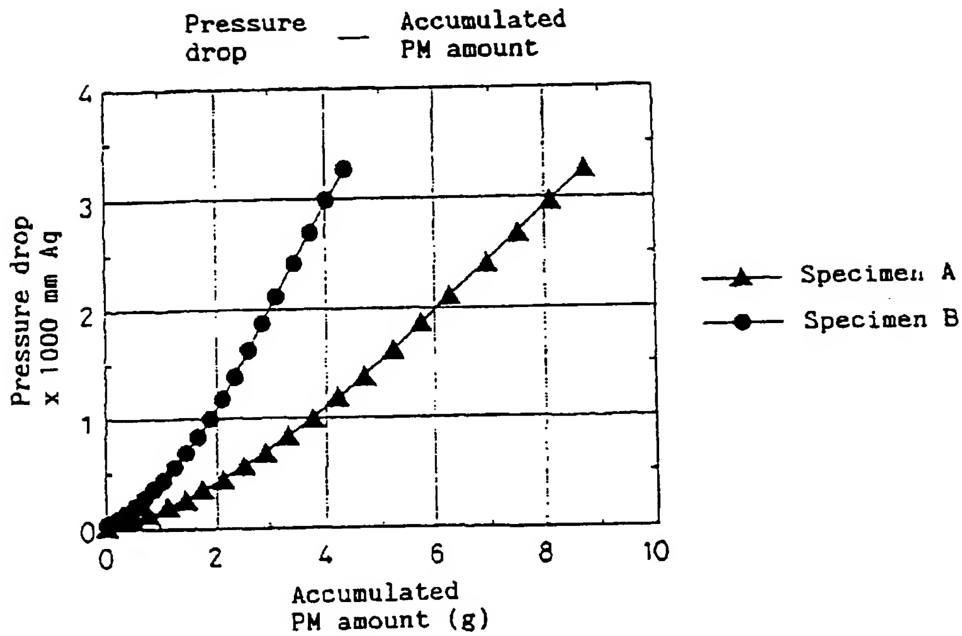
Pressure drop — Accumulated PM amount
Pressure drop x 1000 mm Aq
4
3
2
1
0
0
2
4
6
8
10
Accumulated PM amount (g)
Specimen A
Specimen B

FIG. 8

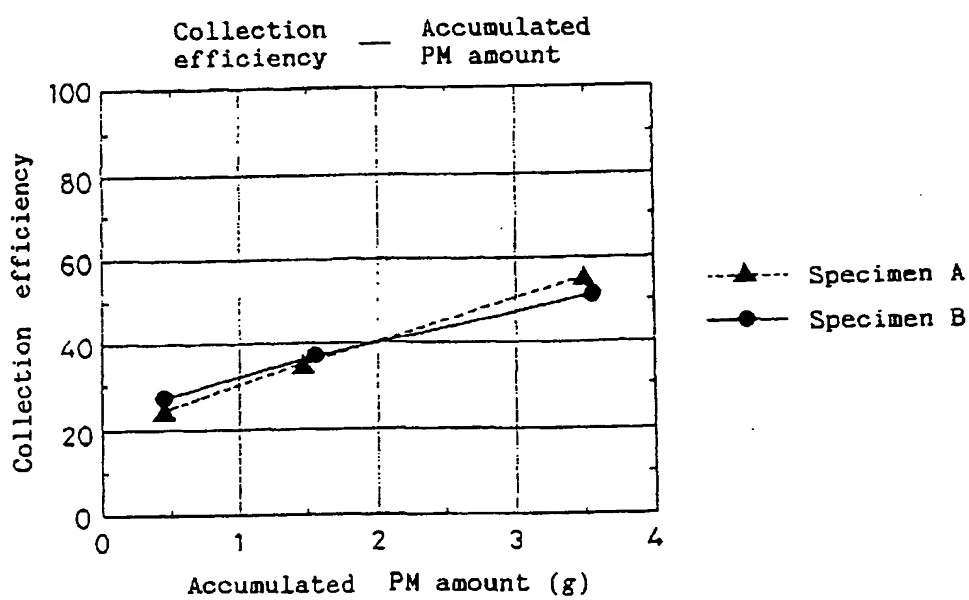
Collection efficiency — Accumulated PM amount
Collection efficiency
100
80
60
40
20
0
0
1
2
3
4
Accumulated PM amount (g)
Specimen A
Specimen B

FIG. 9

Pressure recovery rate

Elapsed time	5 minutes	7.5 minutes	15 minutes
Specimen A	80 %	95 %	100 %
Specimen B	30 %	75 %	100 %

Heater power: 700 W

FIG. 10

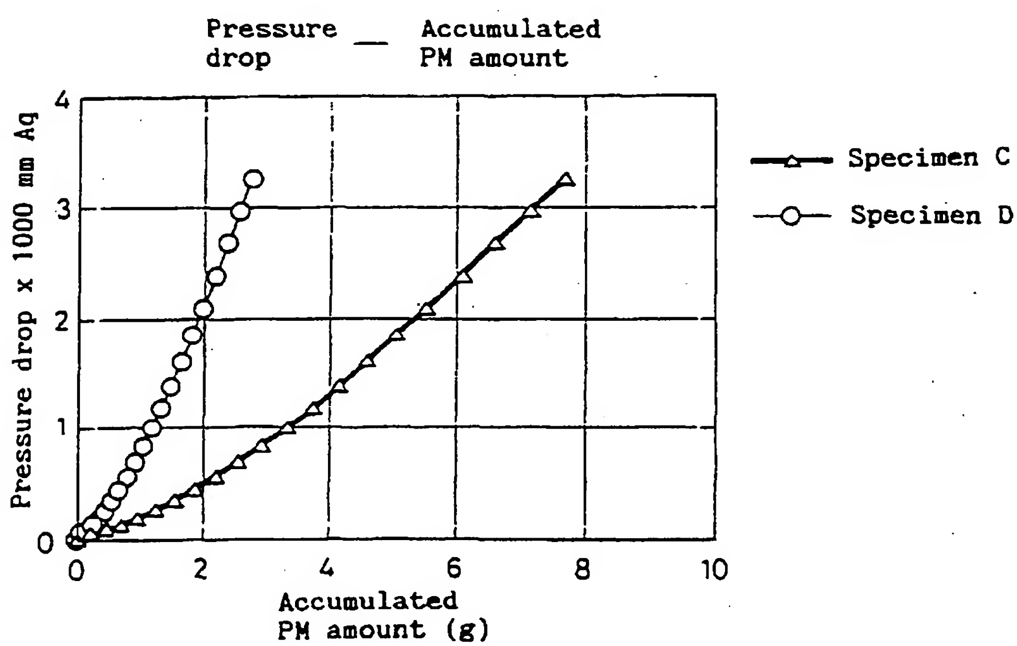

FIG. 11

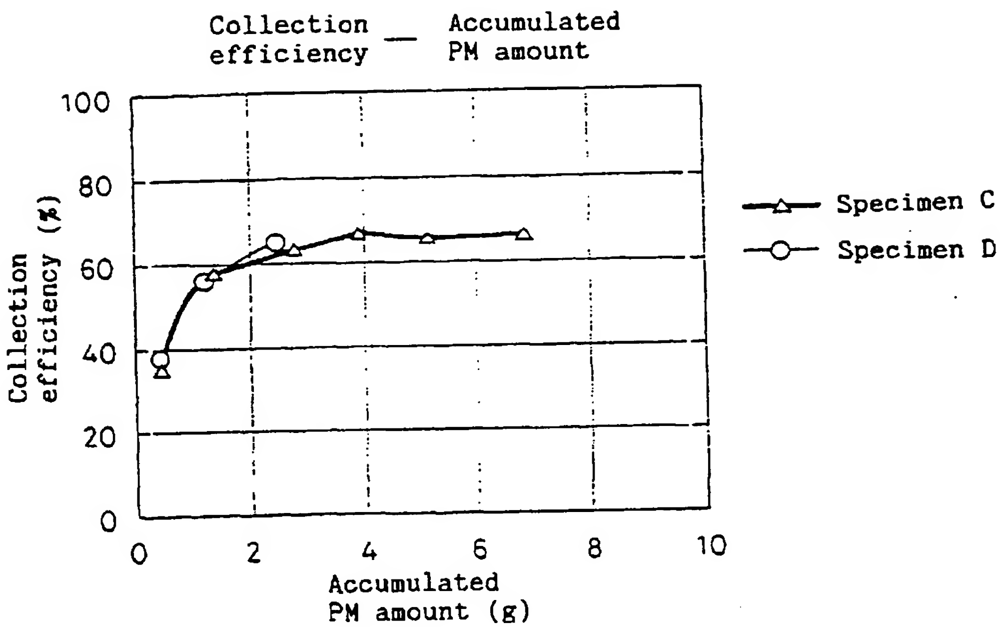

FIG. 12

Pressure recovery rate

Elapsed time	5 minutes	7.5 minutes	15 minutes
Specimen C	85 %	100 %	100 %
Specimen D	40 %	80 %	100 %

Heater power: 700 W

FIG. 13

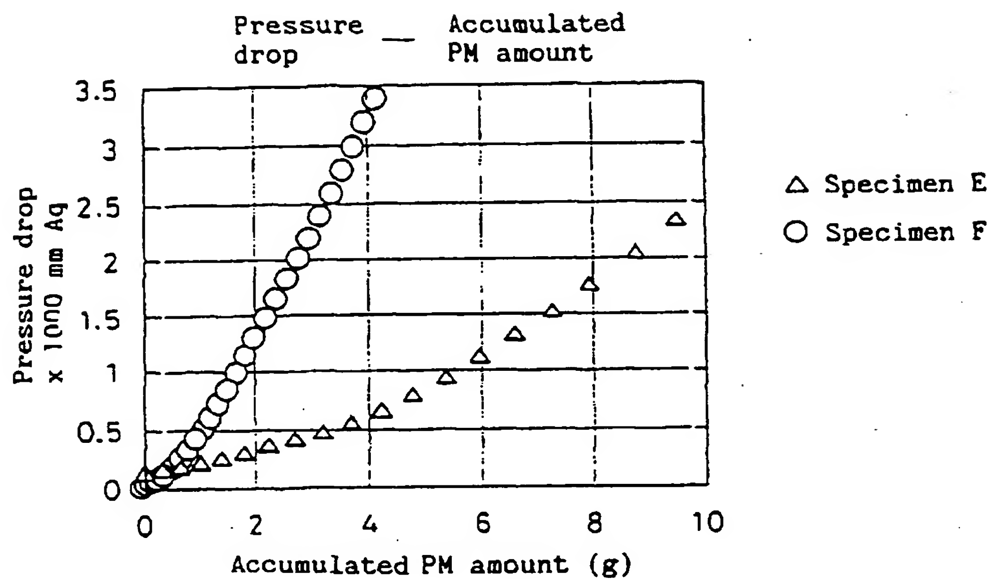
Pressure drop — Accumulated PM amount
3.5
3
2.5
2
1.5
1
0.5
0
Pressure drop x 1000 mm Aq
0
2
4
6
8
10
Accumulated PM amount (g)
Specimen E
Specimen F

FIG. 14

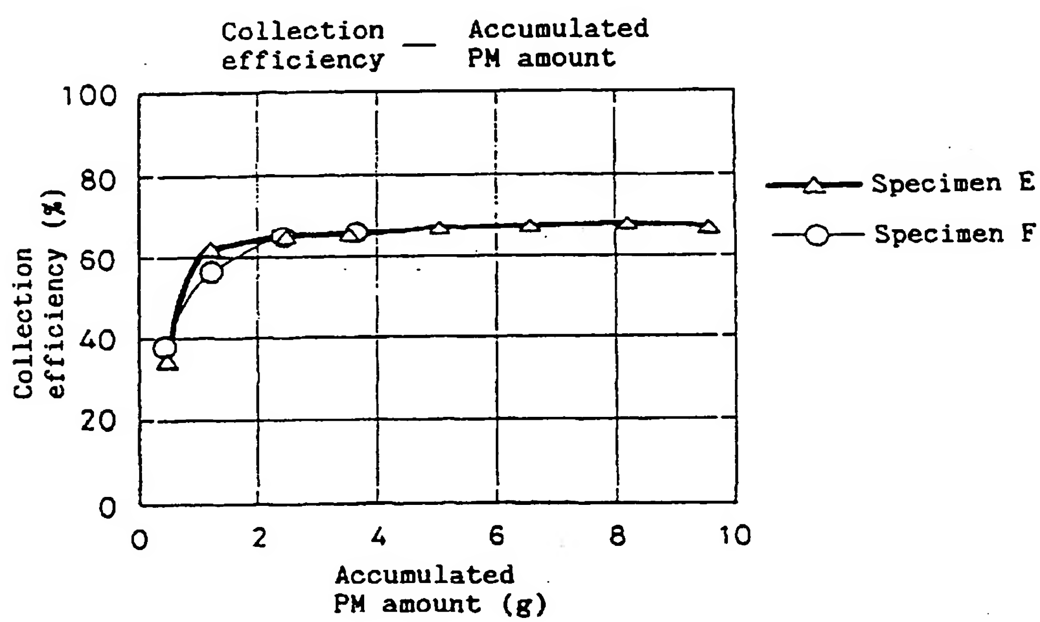
Collection efficiency — Accumulated PM amount
100
80
60
40
20
0
Collection efficiency (%)
0
2
4
6
8
10
Accumulated PM amount (g)
Specimen E
Specimen F

FIG. 15

Pressure recovery rate

Elapsed time	5 minutes	7.5 minutes	15 minutes
Specimen E	85 %	100 %	100 %
Specimen F	35 %	80 %	100 %

Heater power: 700 W